ADVANCED INVENTORY FOR MEDICAL DISTRIBUTOR (AIMD)

Aditya Thorat[1], Sanket Solanke[2], Sumit Thakur[3], Mayur Tidke[4], Aradhna Pawar[5]

[1,2,3,4,5] Department of Computer Engineering, Dr. D. Y. Patil College of Engineering and Innovation, Varale, Talegaon Dabhade, Pune

ABSTRACT

This paper presents the design and implementation of a medicinal inventory system tailored for distributors, integrat- ing advanced AI technologies to streamline inventory manage- ment. The system automates database entry through AI-powered image processing and text analysis, enabling the extraction of relevant data from invoices and bills captured via photos. This eliminates manual data entry, reducing errors and increasing efficiency. Additionally, the system incorporates machine learning (ML) capabilities to predict stockouts by analyzing historical sales data, demand patterns, and inventory trends. It also provides intelligent stock order suggestions to maintain optimal stock levels, ensuring uninterrupted supply. This integrated approach aims to enhance operational efficiency, reduce costs, and improve decision-making for medicinal distributors

KEYWORDS: Medicinal Inventory System, AI Image Processing, Automated Data Entry, Machine Learning, Stockout Prediction, Inventory Optimization, Pharmaceutical Distribution, Bill Image Recognition, Predictive Analytics, Inventory Replenishment

1. INTRODUCTION

In traditional inventory management systems, medical distributors often relied on manual data entry and stock tracking processes, leading to inefficiencies, delays, and human errors. These systems were prone to issues such as inaccurate record- keeping, stock mismanagement, and an inability to predict stockouts, which could disrupt supply chains and result in product shortages. Additionally, manual processes required significant time and effort, making it difficult to maintain realtime inventory updates and respond swiftly to market demands. One of the key limitations of these systems was the manual entry of stock data into databases, which increased the likelihood of errors and delays in stock management [1].

The proposed Advanced Inventory Management System for Medical Distributors (AIMD) addresses these challenges by integrating AI-powered image processing, machine learning (ML), and automated workflows. A key feature of AIMD is the use of Tesseract OCR to automatically extract and input stock information directly from invoices and bills, eliminating the need for manual data entry and significantly improving accuracy and efficiency in database management [2], [3], [4]. Furthermore, the system's ML algorithms provide predictive insights, allowing distributors to forecast stockouts and optimize stock replenishment strategies, reducing wastage and ensuring a stable supply chain [5], [6]. AIMD also incorporates a multirole architecture, tailored for distributors, medical stores, and sales representatives, offering specialized functionalities for each role [1].

In contrast to traditional systems, AIMD ensures real-time accuracy in inventory tracking, minimizes manual effort, and leverages intelligent forecasting for better decision-making. These innovations, backed by advancements in AI and ML, represent a significant leap forward in addressing the limitations of older inventory systems [5], [1].

2. LITERATURE REVIEW

Ashlin Deepa's paper [3] presents an automated invoice processing system utilizing Tesseract OCR to extract essential information from invoices, including vendor details and totals, and formats the data in JSON. Being a perfect match in accor dance to our application, this research implements both text extraction and analysis to formulate the anticipated automation of stock entry into database directly through an image of bill or invoice. The only major limitation is the requirement of good quality of the image for the algorithm to provide satisfactory results.

Navdeep Dhaliwal in his paper [7] have elaborated a study leveraging artificial intelligence to improve inventory management by using ML for forecasting, NLP for data analysis, robotic process automation for task efficiency, and predictive analytics for demand anticipation. The ML used for forecasting proves to be a crucial part of evolution in traditional inventory systems, increasing the efficiency of use by creating smart notifications for stock outs and stock analysis for upcoming orders. Although this evolution increases efficiency, it also increases complexity of implementation. It increases data dependency and showcases a resistance to change. It will also require continuous updates and maintenance regularly for improvement.

Warayut Saena in [8] further progresses in use of ML for predictive forecasting. The research finds that the CNNLSTM model provides the best forecasting results over

1-month, 3-month, and 6-month periods, tailored to specific medicationusage patterns. This research proves to be extremely helpful in our application of the technology. Considering it's merits, the complex model explored in this research also exhibits a risk of overfitting. It can be expected to be problematic in generalizing for different product instances. The stability of the model can only be assumed in certain conditions while it may provide improper results in certain cases.

Kaustubh Sakhare has attempted to perfect the use of ML in his research [5]. The paper explores using predictive analytics and machine learning to manage inventory for perishable goods, focusing on demand forecasting, shelf life, and spoilage prediction. This constitutes the need of expanding data features by including external factors. While increasing the complexity of features, this will also increase dependency on historical data. Even if the overall content of this research diverts to a separate topic, the additional aspect of considering shelf life of perishable products and prediction of their spoilage will prove to be a thriving add-on to our implementation. Prof. Malphedwar in the paper [9] describes a neural network algorithm designed to recognize and validate handwritten equations. Using convolutional layers with varied kernel sizes, it processes input data for accurate recognition and feedback, making it well-suited for efficient text extraction.

3. METHODOLOGY

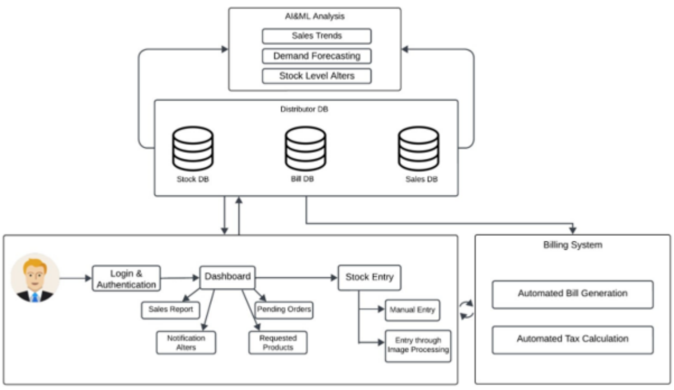

Fig. 1. System Architecture

A. For Distributor

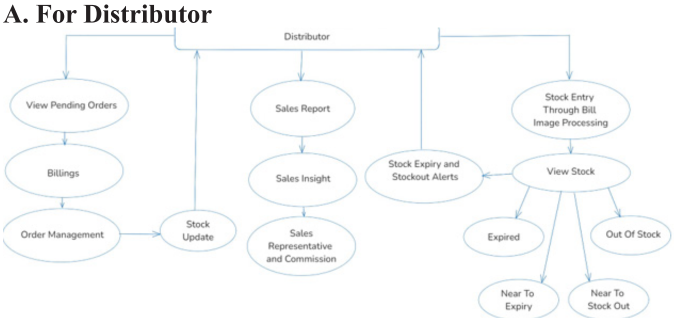

Fig. 2. Distributor Management

The proposed system focuses on automating and streamlining various aspects of distributor management, including order processing, stock tracking, and sales insights. The methodology outlines the key components of the system, broken down as follows:

1. Order Management and Billings: The system begins by allowing distributors to view pending orders, which then proceed through the billings module. This enables automatic generation of invoices and receipts. Subsequently, the orders are passed to the Order Management system, where they are processed and tracked.
2. Stock Management and Alerts: Inventory management is automated using stock entry through bill image processing, which allows stock information to be updated from scanned or photographed bills. The system provides a view stock feature that categorizes products as expired, near to expiry, out of stock, or near to stock out. Additionally, the system generates stock expiry and stockout alerts, helping to maintain a stable supply chain and reducing the risk of shortages or wastage.
3. Sales Insights and Reporting: The system offers tools for sales reporting, which aggregate data for detailed sales insights. This feature helps distributors analyze trends, monitor performance, and predict future sales outcomes. The sales insights module feeds into a sales representative and commission system, which automates the tracking and calculation of commissions based on sales data.
4. Stock Update: Upon successful completion of an order or sales event, the stock update module ensures that inventory is adjusted automatically. This ensures real- time accuracy in stock levels and keeps the entire system synchronized.
5. Sales Representative Management: The system also allows for sales representative management, providing detailed insights on their performance and generating commission data based on predefined criteria linked to sales activity.

B. For Pharmaceutical Store

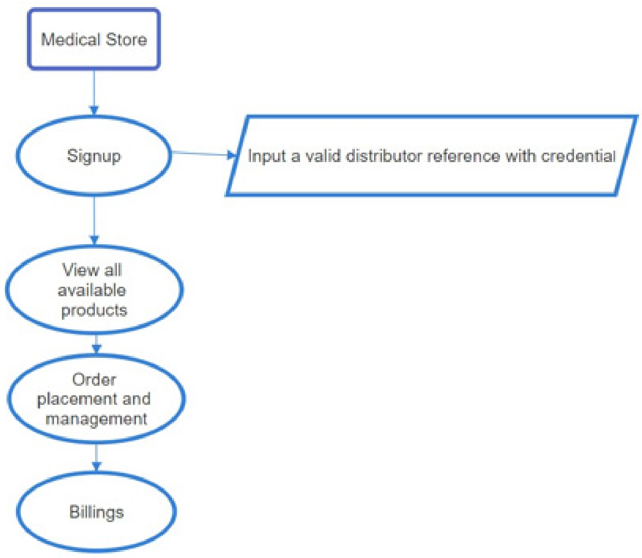

Fig. 3. For Pharmaceutical Store

The methodology outlines the structured process of interacting with the medical store's digital platform. The system begins with a user registration process, where individuals must input valid distributor references and credentials to authenticate their accounts. After successful signup, users can browse through the available medical products. This enables a comprehensive view of all listed items on the platform, including specifics such as

product categories, descriptions, and pricing.

Following the product exploration phase, users can place orders directly through the system. The order placement process ensures that medical store customers can manage their purchases effectively. This includes adjusting quantities, modifying orders, and tracking the status of deliveries. Finally, the billing phase ensures that all transactions are securely recorded. The system generates invoices, provides payment options, and tracks completed and pending payments.

C. For Sales Representative

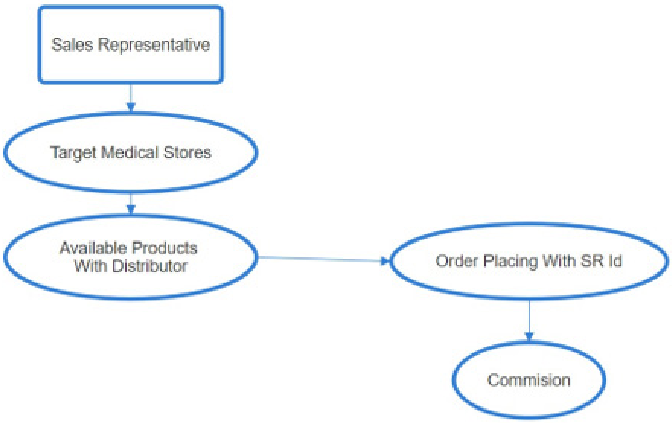

Fig. 4. Sales Representative Management

The methodology outlines the workflow of a sales representative (SR) in managing and fulfilling orders for medical stores through a distributor network. The process begins with the SR identifying and targeting medical stores, establishing a communication channel to introduce the available product range. The SR is responsible for liaising with the stores and providing them with detailed information regarding products that are available through the distributor.

Once the medical stores have access to the product information, they can place orders through the SR, who uses a unique identifier (Referral ID) to process the order. This Referral ID allows the system to track orders and link them back to the specific sales representative, ensuring accountability and transparency throughout the order management process.

Upon successfully placing an order, the system records and verifies the transaction. The sales representative is then eligible for a commission based on the order volume or product type, completing the sales cycle. This commission structure incentivizes SRs to effectively manage and grow their client base, facilitating a mutually beneficial relationship between the distributor, SR, and medical stores.

This methodology ensures that the process is streamlined, from product promotion to order placement and commission disbursement, creating a seamless interaction between all stakeholders.

D. Association Rule

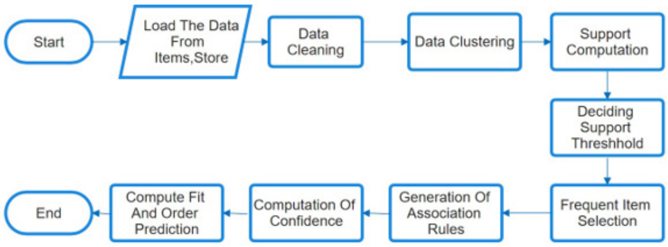

Fig. 5. Apriori Algorithm

Association Rule Mining and the Apriori Algorithm for Market Basket Analysis

Market Basket Analysis (MBA) is a widely used technique in retail to identify patterns of frequently co-occurring items in transactions. By analyzing large datasets of transactions, retail rs can uncover valuable insights about product relationships and customer behavior. One of the most effective techniques for this analysis is Association Rule Mining, which involves finding associations or relationships between various items in a dataset.

The Apriori Algorithm is a popular method for association rule mining, particularly useful for finding frequent itemsets and generating association rules from them. This algorithm helps identify which products are often bought together, enabling retailers to make informed decisions about product placement, cross-selling strategies, and marketing campaigns.

Key Concepts in Association Rule Mining:

1. Support: Support measures how frequently an item or itemset appears in the dataset. It represents the probability of occurrence of an item or itemset in all transactions.
2. Confidence: Confidence is the likelihood that a rule holds true in a transaction. For example, if a rule states that customers who buy bread are likely to buy butter, confidence quantifies how often this association occurs.
3. Lift: Lift measures the strength of the association between items. A lift value greater than 1 indicates that the presence of one item increases the likelihood of the other.

4. APPROACH

A. Stroke Width Transformation (SWT)

Stroke Width Transformation (SWT) is a method in computer vision that enables effective text detection within images, particularly those with complex backgrounds, such as urban scenes, signage, and other environments where text is embedded within intricate surroundings. By emphasizing the consistent stroke width characteristic of text, SWT isolates text regions from cluttered backgrounds, making it an invaluable tool for detecting text in real world imagery.

Working Mechanism of SWT:

1. Stroke Width Detection: SWT initiates by searching for regions where lines, or strokes, exhibit uniform thickness. Since text characters generally maintain a consistent stroke width, they can be identified based on this uniformity.
2. Edge and Gradient Detection: The process begins with edge detection techniques, such as the Canny Edge

Detector, to identify boundaries within the image. Gradient analysis follows, examining the light-to-dark transitions and isolating strokes with opposing gradient directions a typical feature of text.

3. Calculating Stroke Width: SWT measures the distance between opposite edges along each stroke, generating a "stroke width map." Each pixel in this map is assigned a value representing the estimated stroke width, aiding in distinguishing text from other elements.
4. Grouping of Text Regions: Pixels and regions displaying similar stroke widths are grouped to identify possible text zones. Non-text regions are then filtered out, isolating areas that likely contain text.
5. Text Recognition and Conversion: Optical Character Recognition (OCR) is subsequently applied to interpret and convert the identified text regions into digital text.

Applications of SWT

1. Text in Natural Scenes: SWT effectively detects text within complex environments, such as city landscapes, signage, and busy backgrounds.
2. Document Scanning: This method aids in locating text within low-quality or degraded document scans.
3. Augmented Reality (AR): SWT is utilized in real-time AR applications to detect and overlay text on physical objects.
4. Self-Driving Vehicles: SWT enhances autonomous navigation systems by identifying street signs and other textbased cues.

B. Maximum Stable Extremal Regions (MSER)

Maximum Stable Extremal Regions (MSER) is an image processing technique designed to detect stable regions within images. Widely utilized in tasks like text and object recognition, MSER identifies areas based on consistent brightness levels, enabling effective isolation of significant features.

Working Mechanism of MSER

1. Extremal Regions: MSER locates regions in an image where pixels share a consistent brightness level, meaning all pixels within the region are uniformly lighter or darker than the surrounding boundary.
2. Intensity Thresholding: The method progressively adjusts intensity thresholds to detect regions. Regions that persist with minimal size variation across different thresholds are flagged as "stable."
3. Region Stability: A Maximum Stable Extremal Region (MSER) is defined by its ability to retain its structure and size over a range of intensity levels. This stability makes MSER ideal for identifying significant parts of an image that remain consistent despite threshold changes.

Applications of MSER

1. Text Detection: MSER is highly effective for identify- ing text, as characters typically exhibit stable intensity patterns.
2. Object Recognition: Useful for detecting objects with uniform colors or textures, as MSER efficiently highlights regions with similar intensity.
3. Image Matching: MSER aids in locating or matching objects across different images by identifying stable, recurring regions.

C. Text Extraction Process

The text extraction process systematically converts text in images into digital format through four main stages: Localization, Verification, Segmentation, and Recognition. Each stage serves a specific purpose, allowing the system to accurately identify, isolate, and interpret text within images.

1. ***Localization***

   Overview: Localization identifies areas within an image that may contain text. This initial step focuses on narrowing down regions of interest, which enhances processing efficiency in the following steps.

   How It Works: During localization, algorithms scan the image to detect patterns likely to contain text, using techniques like edge detection, region proposals, or stroke analysis (e.g., SWT or MSER). The output is a set of bounding boxes around potential text areas for further processing.

2. ***Verification***

   Overview: The verification stage assesses whether the localized areas indeed contain text, filtering out nontext elements to reduce false positives.

   How It Works: Verification examines each candidate region for characteristics typical of text, such as stroke consistency, width, and alignment. Classifiers or featurebased techniques evaluate whether these regions resemble text patterns, retaining only verified areas for segmentation.

3. ***Segmentation***

   Overview: Segmentation separates individual text components within the verified regions, isolating characters or words to prepare them for accurate recognition.

   How It Works: Segmentation breaks down text regions into individual characters or groups by examining spacing, strokes, and contours. Techniques like connected component analysis and contour tracing help isolate clustered text, creating distinct units ready for recognition.

4. ***Recognition***

   Overview: In the recognition stage, the system interprets and converts segmented text into digital characters, completing the extraction process.

   How It Works: Optical Character Recognition (OCR) or similar algorithms analyze each isolated unit to identify characters. These characters are then assembled into words and sentences, converting the visual text into a machinereadable format that can be stored, edited, or further analyzed.

5. FEASIBILITY OF THE PROJECT

This project is technically, economically, and operationally feasible based on the following factors:

1. **Technical Feasibility:**
   The project leverages established technologies such as AI and machine learning (ML) all of which have proven to be effective in inventory management and process automation.

   With access to frameworks like Django for development and MongoDB for database management, along with Tableau for data visualization, the technical requirements are well-supported by modern tools and platforms.

   The use of Tesseract OCR for automated stock entry and ML algorithms for demand forecasting can be implemented with readily available libraries and technologies.

2. **Economic Feasibility:**
   The development costs are manageable, with many of the tools being opensource (e.g., Tesseract, MongoDB, and Python libraries for ML).

   Long-term benefits, such as reduced labor costs, minimized stockouts, and optimized inventory management, outweigh initial development and integration expenses. Medical distributors are likely to see significant cost savings through improved accuracy, automation of financial processes, and reduced stock wastage.

3. **Operational Feasibility:**
   The system is designed to be user-friendly, requiring minimal training for medical distributors and staff to operate. By automating manual tasks like stock entry and billing, the system reduces human error and workload, making operations more efficient.

   Real-time inventory management and predictive analysis using AI ensure that the application aligns with the dynamic needs of the healthcare industry.

6. SCOPE OF THE PROJECT

1. **Real-Time Inventory Management:**
   Implement image processing technologies, such as tesseract OCR, for real-time stock entry and tracking, ensuring accurate and instant inventory updates.

2. **Automated Data Entry:**
   Utilize AI-powered image processing to automate the entry of stock data from bills and invoices, reducing manual errors and streamlining workflows.

3. **Machine Learning for Data Analysis:**
   Employ machine learning algorithms to analyze historical sales and stock data, providing insights into sales trends, demand forecasting, and optimal stock levels.

4. **Financial Process Automation:**
   Integrate features for automated bill generation, tax calculations, and financial recordkeeping to simplify and speed up financial processes.

5. **Proactive Inventory Control:**
   Implement a notification system to alert distributors about expiring stock, low inventory levels, and potential stockouts, minimizing waste and ensuring optimal stock availability.

6. **Distributor-Store Interconnectivity**:
   Create a robust infrastructure that facilitates a one to many connection between medical distributors and stores, fostering stronger loyalty between distributors and their clients.

7. LIMITATIONS OF THE PROJECT

1. **Initial Setup and Integration Costs:**
   Implementing an AI-driven system requires significant investment in infrastructure, such as integrating AI image processing, machine learning models, and custom software development. For small or mediumsized distributors, these upfront costs can be prohibitive.

2. **Dependence on Historical Data for Predictions:**
   Machine learning models for stockout prediction and inventory optimization depend on historical sales and inventory data. If the data is incomplete, insufficient, or contains anomalies, the predictive accuracy of the models will be compromised. Additionally, sudden changes in market conditions, such as a surge in demand due to a health crisis, may not be captured by the model's predictions.

3. **Limited Flexibility with New Products:**
   When new products are introduced, the system may take time to learn buying patterns and associations between these products and existing ones. This could result in inaccurate stock predictions or inefficient recommendations until sufficient data is collected.

4. **Security and Privacy Concerns:**
   Handling sensitive information such as medical supplies, orders, and financial data requires stringent security measures. AI systems must ensure that data is protected from cyber threats, unauthorized access, and data breaches, especially given the critical nature of pharmaceutical distribution.

5. **Complexity of Inventory Management Across Multiple Locations:**
   Distributors operating across multiple locations may face challenges in synchronizing inventory data across different warehouses or branches. Discrepancies between stock levels at various locations can complicate the automation process and lead to errors in predictions or recommendations.

6. **User Training and Adaptation:**
Employees and stakeholders such as medical store own- ers, sales representatives, and distributors need to be trained to use the system effectively. There might be a learning curve for users unfamiliar with AI-powered systems, which could lead to delays in adoption or errors in operation.

8. CONCLUSION

The AI-powered medicinal inventory system discussed in this paper offers a practical solution by using image processing to automatically extract data from bills and invoices, reducing the need for manual data entry. It also applies machine learning algorithms to predict stockouts and suggest optimal stock orders, helping distributors maintain the right amount of inventory. Additionally, the system provides separate logins for distributors, medical stores, and sales representatives, each with customized features to improve their experience and streamline operations.

Despite its many benefits, the system does have some limitations, such as high initial setup costs, reliance on data quality, and the need for proper training of users. However, with careful implementation and continuous improvement, these challenges can be managed, and the system has the potential to greatly improve inventory management in the pharmaceutical industry. Overall, this review highlights how AI and machine learning technologies can be effectively used to enhance efficiency, reduce errors, and optimize decision-making in medicinal inventory management. As the technology continues to evolve, these systems will become even more essential for distributors looking to stay competitive and meet the growing demands of the healthcare sector.

REFERENCES

1. A. Mostofi and V. Jain, "Inventory management and control of deteri- orating pharmaceutical products sing industry 4.0," in 2021 IEEE 8th International Conference on Industrial Engineering and Applications (ICIEA), pp. 394–400, IEEE, 2021.
2. Y.-M. Su, H.-W. Peng, K.-W. Huang, and C.-S. Yang, "Image processing technology for text recognition," in 2019 International Conference on Technologies and Applications of Artificial Intelligence (TAAI), pp. 1–5, IEEE, 2019.
3. A. Deepa, S. Chinta, N. K. Ashili, B. S. Babu, R. R. Vydugula, and R. S. VSL, "An intelligent invoice processing system using tesseract ocr," in 2024 International Conference on Advances in Data Engineering and Intelligent Computing Systems (ADICS), pp. 1–6, IEEE, 2024.
4. C. Kaundilya, D. Chawla, and Y. Chopra, "Automated text extraction from images using ocr system," in 2019 6th International Conference on Computing for Sustainable Global Development (INDIACom), pp. 145– 150, IEEE, 2019.
5. K. V. Sakhare and I. Kulkarni, "Predictive analysis of end to end inventory management system for perishable goods," in 2022 3rd International Conference for Emerging Technology (INCET), pp. 1–5, IEEE, 2022.
6. K. Praveen, P. Kumar, J. Prateek, G. Pragathi, and J. Madhuri, "Inventory management using machine learning," International Journal of Engineer- ing Research & Technology (IJERT), vol. 9, no. 06, pp. 866–869, 2020.
7. N. Dhaliwal, P. K. Tomar, A. Joshi, G. S. Reddy, A. Hussein, and M. B. Alazzam, "A detailed analysis of use of ai in inventory management for technically better management," in 2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), pp. 197–201, IEEE, 2023.
8. W. Saena and V. Suttichaya, "Predicting drug sale quantity using machine learning," in 2019 14th International Joint Symposium on Artificial Intelligence and Natural Language Processing (iSAI-NLP), pp. 1–6, IEEE, 2019.
9. S. A. Abhishek, S. Raj, and L. Malphedwar, "Evaluation of handwritten mathematical equations," International Journal of Advanced scientific Research and engineering trends, 2004.